US006377387B1

(12) **United States Patent**
**Duthaler et al.**

(10) **Patent No.: US 6,377,387 B1**
(45) **Date of Patent: Apr. 23, 2002**

(54) **METHODS FOR PRODUCING DROPLETS FOR USE IN CAPSULE-BASED ELECTROPHORETIC DISPLAYS**

(75) Inventors: **Gregg M. Duthaler**, Brookline; **Andrew L. Loxley**, Allston, both of MA (US)

(73) Assignee: **E Ink Corporation**, Cambridge, MA (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/543,639**

(22) Filed: **Apr. 6, 2000**

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 09/413,009, filed on Oct. 6, 1999, now Pat. No. 6,262,833.
(60) Provisional application No. 60/127,964, filed on Apr. 6, 1999.

(51) **Int. Cl.**[7] ..... **G02B 26/00**; B01J 13/02

(52) **U.S. Cl.** ..... **359/296**; 345/107; 264/4; 264/4.1; 424/450

(58) **Field of Search** ..... 359/296, 452; 264/4, 4.1, 4.3, 8, 15; 345/108, 107, 105; 424/450, 1.21, 9.52

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 2,766,478 | A | 10/1956 | Raley, Jr. et al. |
| 2,800,457 | A | 7/1957 | Green et al. |
| 3,036,388 | A | 5/1962 | Tate |
| 3,384,488 | A | 5/1968 | Tulagin et al. |
| 3,389,194 | A | 6/1968 | Somerville |
| 3,406,363 | A | 10/1968 | Tate |
| 3,423,489 | A | 1/1969 | Arens et al. |
| 3,460,248 | A | 8/1969 | Tate |
| 3,585,381 | A | 6/1971 | Hodson et al. |
| 3,612,758 | A | 10/1971 | Evans et al. |
| 3,668,106 | A | 6/1972 | Ota |
| 3,670,323 | A | 6/1972 | Sobel et al. |
| 3,756,693 | A | 9/1973 | Ota |
| 3,767,392 | A | 10/1973 | Ota |
| 3,772,013 | A | 11/1973 | Wells |
| 3,792,308 | A | 2/1974 | Ota |
| 3,806,893 | A | 4/1974 | Ohnishi et al. |
| 3,850,627 | A | 11/1974 | Wells et al. |
| 3,870,517 | A | 3/1975 | Ota et al. |

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| CH | 563 807 | 7/1975 |
| EP | 0 186 710 A1 | 7/1986 |
| EP | 0 240 063 B1 | 10/1987 |

(List continued on next page.)

OTHER PUBLICATIONS

Anders (1986), "Monodisperse Droplet Streams and Their Application in Space," *Proc. Symp. Fluid Dynam.,* pp. 119–125.

Ballinger et al., (Mar. 1973) "Magnetic Recording Paper is Erasable," *Electronics, ,* pp. 73–76.

Beilin et al., (1986) "8.5: 2000–Character Electrophoretic Display," *SID 86 Digest, ,* pp. 136–140.

(List continued on next page.)

*Primary Examiner*—Loha Ben
(74) *Attorney, Agent, or Firm*—Testa, Hurwitz & Thibeault, LLP

(57) **ABSTRACT**

Methods are provided for forming a dispersion of substantially uniform droplets. An internal phase that includes a plurality of particles suspended in a first fluid is provided and an external phase including a second fluid is provided. The internal phase is vibrated and the internal phase is applied to the external phase. Either the internal phase or a combination of the internal and external phases form a series of droplets or complex droplets of substantially uniform size.

**22 Claims, 17 Drawing Sheets**